

# Automatic Waste Sorter Machine using Proximity Sensor

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**Keywords:** Capacitive Proximity Sensor; Inductive Proximity Sensor; Microcontroller; PIR Sensor; Ultrasonic Sensor, Waste Sorter Machine

**Abstract:** The waste problem is not a new thing anymore in Indonesia. Public awareness is still lacking not to litter. One solution that can be done is to make a special trash bin so that it is easy when sorting out which the waste can be disposed of at a landfill or to be recycled. Therefore, in this study an automatic waste sorter machine was made. This machine can sort metal trash, plastic bottles, or not both, which are sorted the waste will be put in different bins according to type. In this machine, Arduino Mega 2560 is used as the main brain, which will work according to the input obtained from PIR sensor, LDR sensor, inductive proximity sensor, capacitive proximity sensor, and ultrasonic sensor. Testing on automatic waste sorter machine is carried out using five types of waste, namely cans, non-transparent plastic bottles that contain water, transparent plastic bottles, transparent plastic, and report books. From the test results obtained that the automatic waste sorter machine can detect waste entering the trash can according to its type by 72%. Whereas 28% experienced a detection error, which was the biggest error occurred in the detection of transparent empty plastic bottles.

## 1 INTRODUCTION

The problem of waste is not new anymore, especially in Indonesia. Waste has become a severe problem. Lack of awareness from the community is one of the causes. Many people still litter, for example, in sewers, rivers or the sea. According to a survey conducted by BPS in 2018 there were 72% of the public not yet concerned about waste management, even 81% of plastic waste is dumped into the sea so that it will be very dangerous to the sustainability of the oceans (García Nieto *et al.*, 2018). In 2025 it is predicted that plastic waste entering the sea will increase, if there is no improvement in waste management (Jambeck *et al.*, 2015). One solution that can be done is to make a special trash bin so that it is easy when sorting out which rubbish can be disposed of in landfills or which will be recycled.

In some studies a smart trash bin has been created which can provide information if the trash bin is full (Fadel, 2017), (Zavare *et al.*, 2017), (Navghane, Killedar and Rohokale, 2016), but sorting has not been done for the type of waste included. Subsequent research has made waste sorting machines, but on machines made using conveyors (Wath and Ughade, 2019), (Jude *et al.*, 2019), (Chaithanya *et al.*, 2017), (Samreen *et al.*, 2017), (Williams and Bentil, 2016),

(Ranjitha *et al.*, 2018), (Engineering, 2019), (Chahine and Ghazal, 2017). This is certainly not suitable for a small-scale trash bins because to make or buy it requires expensive costs. Therefore, in this study, an automatic waste sorter machine designed for a small-scale was created. This machine uses an inductive proximity sensor to detect metal waste and a capacitive proximity sensor to detect plastic bottle waste. These sensors were chosen because they have been proven to be able to sort out different types of waste (Chahine and Ghazal, 2017), (Pushpa *et al.*, 2015), (C, Badami and H, 2017). Then this machine is equipped with a PIR sensor to detect whether or not people are going to throw waste, thus making opening and closing the trash cans automatically. In addition, there are also a LDR sensors and an ultrasonic sensors as additional detectors so that bins become smart (Mapari *et al.*, 2020). The LDR sensor is used to detect whether the waste has entered to the trash can and the ultrasonic sensor is used as a warning when the trash can is full.

## 2 METHOD

### 2.1 System Description

The tool made is an automatic waste sorter machine. In this machine, uses the Arduino Mega 2560 microcontroller as the main brain. The shape of the Arduino Mega 2560 microcontroller is as shown in Figure 1. This board has relatively many input/output pins, namely 54 digital input/output pins of which 15 pins can be used as Pulse Width Modulation (PWM) outputs, 16 pins as analog inputs, 4 pins as UART (hardware serial port), 16 MHz crystal oscillator, USB connection, jack power, header ICSP, and reset button. Of course this makes it easier for us to make tools.

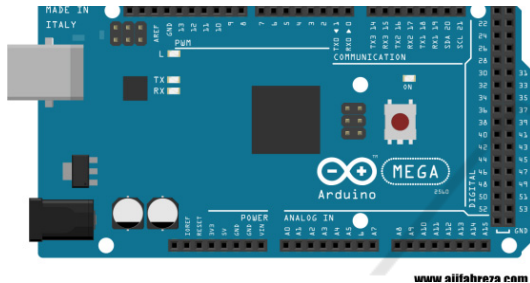


Figure 1: The Arduino Mega 2560 Microcontroller.

In an automatic waste sorter machine, arduino will work based on input obtained from Passive Infrared Sensor (PIR) sensor, Light-Dependent Resistor (LDR) sensor, inductive proximity sensor, capacitive proximity sensor, and ultrasonic sensors. Then as the output on this machine used a servo motor and buzzer. The servo motor functions to push or rotate the trash can cover with a high degree of precision in terms of angle position, acceleration, and speed. While the buzzer functions as a warning sound when the trash can is full. The block diagram of this automatic waste sorter machine is shown in Figure 2.

The PIR sensor is a sensor that can detect movement, has a small size, requires small power, and is quite easy to use, so it is suitable for use on small-scale machine, such as this automatic waste sorter machine. The shape of the PIR sensor is as shown in Figure 3. In this machine, the PIR sensor functions to detect whether someone is going to take out the trash or not.

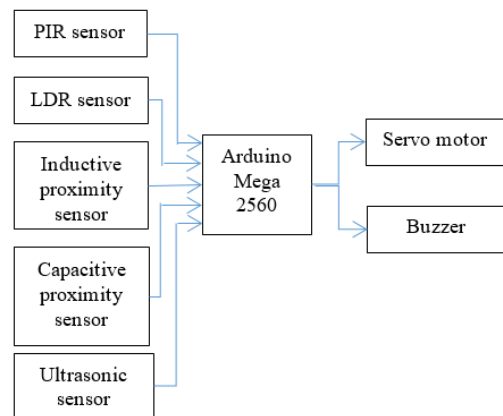


Figure 2: The block diagram of an automatic waste sorter machine.



Figure 3: The PIR sensor.

The LDR sensor is a resistor component whose resistance value will vary according to the intensity of light hitting this sensor. The more light hitting the LDR sensor, the resistance value will decrease. Conversely, the less light hitting the LDR sensor, the greater the resistance value so that it will inhibit the electric current flowing. The shape of the LDR sensor is as shown in Figure 4. In an automatic waste sorter machine, the LDR sensor functions as a detector to detect whether trash has been put in the trash can or not.



Figure 4: The LDR sensor.

The proximity sensor is a sensor that is able to detect objects that are close to within the detection limit of the sensor even without touching. This sensor detects the presence of objects using electromagnetic fields or electromagnetic radiation rays to determine whether there are certain objects around them. There are several types of proximity sensors, which in this automatic waste sorter machine uses an inductive

proximity sensor a capacitive proximity sensor. The inductive proximity sensor functions as a detector whether the incoming waste is metal waste or not. The shape of the inductive proximity sensor is shown in Figure 5. While the capacitive proximity sensor functions as a detector for incoming waste in the form of plastic bottles or not. The shape of the capacitive proximity sensor is shown in Figure 6.



Figure 5: The inductive proximity sensor.



Figure 6: The capacitive proximity sensor.

The ultrasonic sensor is a distance sensor that is able to read a distance of approximately 2 cm to 4 meters. The ultrasonic sensors work by emitting ultrasonic waves, which are waves used to detect the presence of an object by estimating the distance between the sensor and the object. The shape of the ultrasonic sensor is shown in Figure 7. In an automatic waste sorter machine, the ultrasonic sensor detects whether the trash can is full or not.



Figure 7: The ultrasonic sensor.

## 2.2 Automatic Waste Sorter Machine Design

The PIR sensor is placed in the top position of the lid of the outside of the trash that serves to detect whether there is movement or not on top of the trash, which in this case if there is movement means someone will dispose of waste. The LDR sensor is placed on the lid

of the first inner bin, which serves as a detector whether or not waste is put in the bin. Then in this tool used two types of proximity sensors, namely inductive proximity sensors and capacitive proximity sensors. The inductive proximity sensor is placed on the lid of the first inner bin, which is adjacent to the LDR sensor, which functions as a detector for incoming waste in the form of metal waste or not. Whereas the capacitive proximity sensor is placed on the lid of the second inner bin, which serves as a detector for incoming waste in the form of plastic bottles or not. Then as a complement to this machine there is also an ultrasonic sensor as a detector when the trash bin is full. Because this machine uses three bins, there are also three ultrasonic sensors.

The workings of the automatic waste sorter machine made can be seen in Figure 8, which starts with a PIR sensor that detects whether there is movement or not on the trash bin. If a movement is detected above the trash can, it means that someone will throw the trash, so the servo motor 1 will rotate 170°. In this case, it means that the outer lid of the trash can will open automatically so that waste can be put into the trash. Then on the inside of the trash bin there are two more lids on the trash bin, which will also work automatically based on the input it receives.

In an automatic waste sorter machine, when waste enters the trash, the process is that the incoming waste is first collected in the lid of the first inner trash can. On the lid of the first inner trash bin there is an LDR sensor equipped with an Light-Emitting Diode (LED) so that the reading is more accurate, which is the process if there is waste in this lid then the LDR will read the dark. In this case, it means that garbage has been detected that has entered the trash and the waste sorting process will be carried out.

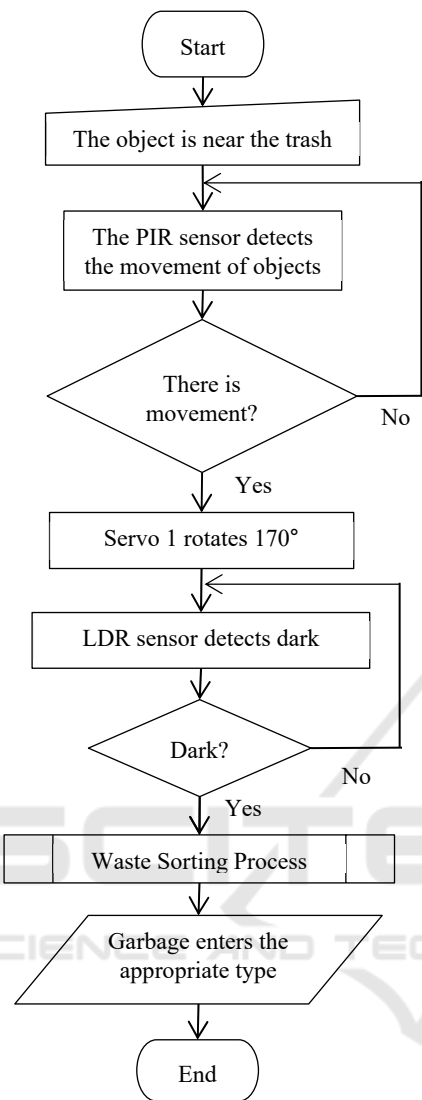


Figure 8: Automatic waste sorter machine flowchart.

The flowchart of the waste sorting process can be seen in Figure 9. The process begins with an inductive proximity sensor that will work to detect waste entering the lid of the first inner trash bin whether metal or not. The inductive proximity sensor is placed on the lid of the first inner trash can, which is next to the LDR sensor. The process is if the inductive proximity sensor detects metal waste, the servo motor 2 which is also on the lid of the first inner trash bin can will rotate 0° so that the metal waste will enter the metal trash can. However, if the inductive proximity sensor detects it is not metal waste, the servo motor 2 which is on the lid of the first inner trash bin will rotate 90° so that the waste will enter the lid of the second inner trash bin.

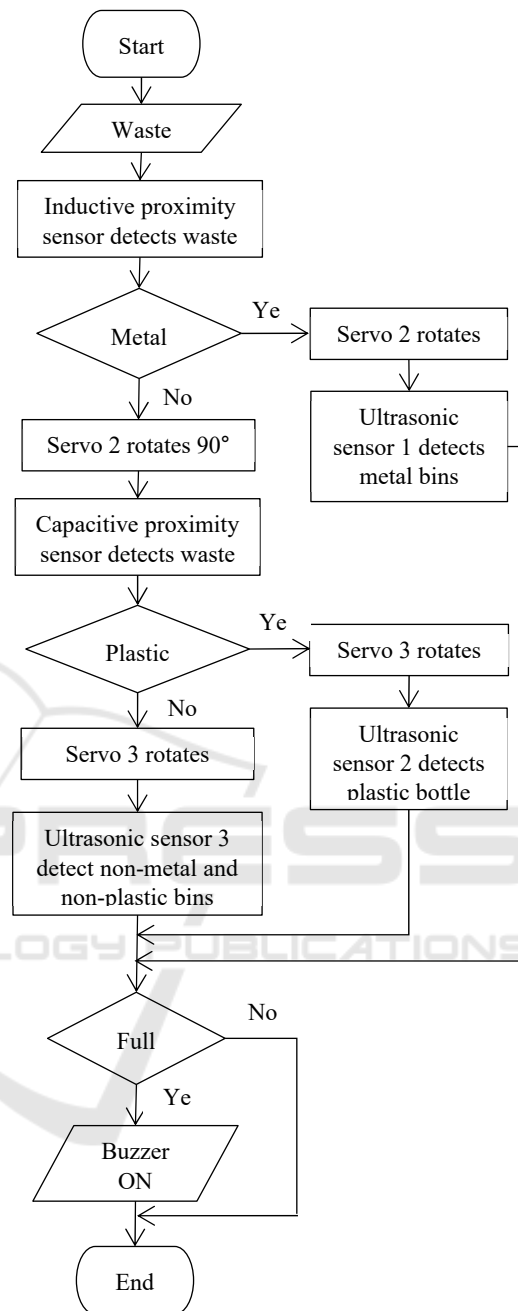


Figure 9: The flowchart of the waste sorting process.

On the lid of the second inner trash bin, there is a capacitive proximity sensor that detects incoming waste in the form of plastic bottles or not. If the capacitive proximity sensor detects plastic bottle bins, servo motor 3 which is on the lid of the second inner trash bin will rotate 0° so that the plastic bottle bins will enter the plastic bottle trash bin. However, if the capacitive proximity sensor detects that it is not plastic bottle bins, servo motor 3 which is on the lid

of the second inner trash bin, will rotate 110° so that the waste will enter the non-metal and not plastic bottles trash bin. After the waste enters the appropriate type of waste, then the ultrasonic sensor will detect whether the trash bin is full or not. In this machine three trash bins are used so that there are also three ultrasonic sensors, namely ultrasonic sensor 1 placed in metal bins, ultrasonic sensor 2 placed in plastic bottle bins, and ultrasonic sensor 3 placed in non-metal and also not a plastic bottle bins. If any of the three ultrasonic sensors detect that the trash bin is full, the buzzer will sound as a warning sign.

### 3 RESULTS AND DISCUSSIONS

The results of making an automatic waste sorter machine are shown in Figure 10. The description of the numbering in the image is :

1. Tool wall
2. Power supply 12V 5A
3. Cover the second inner bin
4. Tool framework
5. Trash that is neither metal nor plastic bottle
6. Cover the first inner bin
7. Arduino Mega 2560
8. Metal trash can
9. Plastic bottle trash can

In Figure 10, the lid of the trash can number 6 is the place for the LDR sensor, inductive proximity sensor, and also the servo motor 2. Then for the placement of the PIR sensor, servo motor 1, and buzzer is the top position on the outer trash can cover, which is located just above number 6. While the lid of the trash bin number 3 is the place for the capacitive proximity sensor and the servo motor 3.

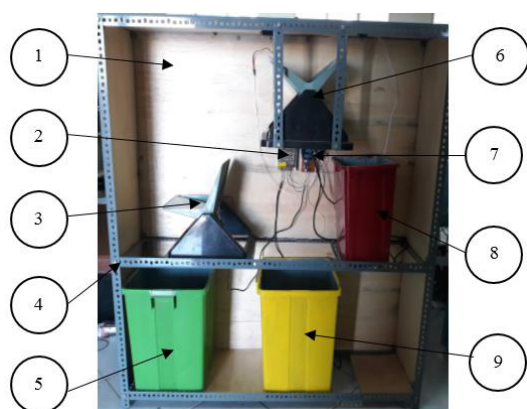


Figure 10: The results of making an automatic waste sorter machine.

Experiments on the automatic waste sorter machine were carried out using five types of waste, namely cans, non-transparent plastic bottles filled with water, transparent empty plastic bottles, plastic, and report books. Each type of waste was tested ten times, the results are shown in Table 1, Table 2, Table 3, Table 4, and Table 5.

The results of automatic waste sorter machine testing using cans waste are shown in Table 1. At ten times the experiment carried out trash can be announced as metal waste. This shows that the detection has been done 100% correct.

Table 1: Automatic waste sorter machine testing results for cans waste.

Trial to-	Cans included in the category		
	Metal	Plastic	Not Both
1	√	-	-
2	√	-	-
3	√	-	-
4	√	-	-
5	√	-	-
6	√	-	-
7	√	-	-
8	√	-	-
9	√	-	-
10	√	-	-
Percentage	100%	0%	0%

In Table 2 is the result of testing the automatic waste sorter machine using the waste of non-transparent plastic bottles filled with water. In ten experiments that have been carried out the waste of non-transparent plastic bottles filled with water were detected as plastic waste. This of course also shows that the detection has been done is 100% correct.

Table 2: Automatic waste sorter machine testing results for the waste of non-transparent plastic bottles filled with water.

Trial to-	The waste of non-transparent plastic bottles filled with water included in the category		
	Metal	Plastic	Not Both
1	-	√	-
2	-	√	-
3	-	√	-
4	-	√	-
5	-	√	-
6	-	√	-
7	-	√	-
8	-	√	-
9	-	√	-
10	-	√	-
Percentage	0%	100%	0%

In Table 3 is the result of testing the automatic waste sorter machine using transparent empty plastic bottles bins. In ten experiments that have been carried out, transparent empty plastic bottles are detected as non-metal and non-plastic waste (not both). This certainly shows that the detection that has been done is 100% wrong, because empty plastic bottles that are transparent should be included in the type of plastic waste.

Table 3: Automatic waste sorter machine testing results for transparent empty plastic bottles.

Trial to-	Transparent empty plastic bottles included in the category		
	Metal	Plastic	Not Both
1	-	-	√
2	-	-	√
3	-	-	√
4	-	-	√
5	-	-	√
6	-	-	√
7	-	-	√
8	-	-	√
9	-	-	√
10	-	-	√
Percentage	0%	0%	100%

In Table 4 is the result of testing the automatic waste sorter machine using plastic waste. In ten experiments carried out plastic waste was detected as non-metal and non-plastic waste (not both). This shows that the detection has been done 100% correct.

Table 4: Automatic waste sorter machine testing results for plastic waste.

Trial to-	Plastic included in the category		
	Metal	Plastic	Not Both
1	-	-	√
2	-	-	√
3	-	-	√
4	-	-	√
5	-	-	√
6	-	-	√
7	-	-	√
8	-	-	√
9	-	-	√
10	-	-	√
Percentage	0%	0%	100%

In Table 5 is the result of testing automatic waste sorter machine using the report book waste. In the ten experiments that have been carried out, the report book waste is twice detected as plastic waste and three times it is detected as non-metal and non-plastic waste. This shows that the detection has been done is

only 60% correct, while the 40% experienced an error because the report book waste is detected as plastic.

Table 5: Automatic waste sorter machine testing results for report book waste.

Trial to-	Report book included in the category		
	Metal	Plastic	Not Both
1	-	√	-
2	-	-	√
3	-	-	√
4	-	-	√
5	-	√	-
6	-	√	-
7	-	-	√
8	-	-	√
9	-	√	-
10	-	-	√
Percentage	0%	40%	60%

## 4 CONCLUSIONS

From the test results, it can be concluded that 72% the automatic waste sorter machine can detect waste entering the trash according to its type. Then the automatic waste sorter machine has a detection error of 28%. The biggest error occurred in detecting transparent empty plastic bottles. This is because capacitive proximity sensors are more sensitive if the plastic bottles detected are not transparent.

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